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(71) Applicant
Standard Telephones and Cables Public Limited Company, (United Kingdom),
190 Strand, London WC2R IDU

(72) Inventors
William Alden Crossland,
Robert Walter Alister Scarr,
Jack Rowland Peters,
Peter William Ross,
Frank Astorino

(74) Agent and/or Address for Service
S. R. Capsey,
S T C Patent Department, Edinburgh Way,
Harlow, Essex CM20 2SH

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(56) Documents cited
GB A 2118347   GB A 2079022
GB A 2113444   GB A 2065943
GB A 2110857   GB A 2029614

(58) Field of search
G4H
G5C

(54) **Data terminals**

(57) A data terminal uses as its display device a liquid crystal display formed on one face of a thin silicon slice. The slice has formed in it the controlling circuitry, based on MOS devices, for the display and some at least of the associated circuitry. The controlling circuitry includes a microprocessor with its associated memories and interfaces.
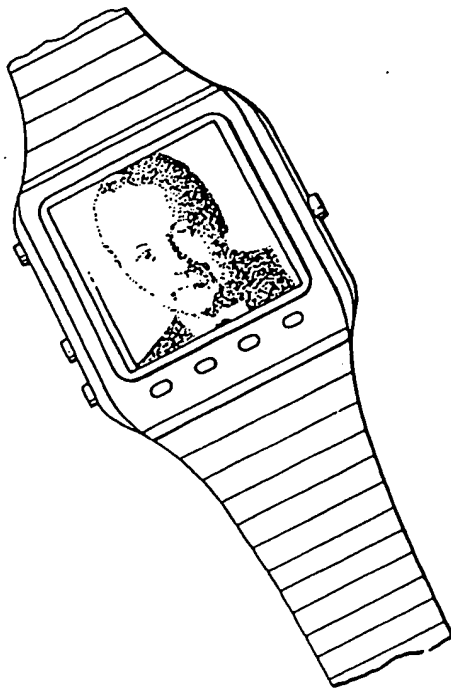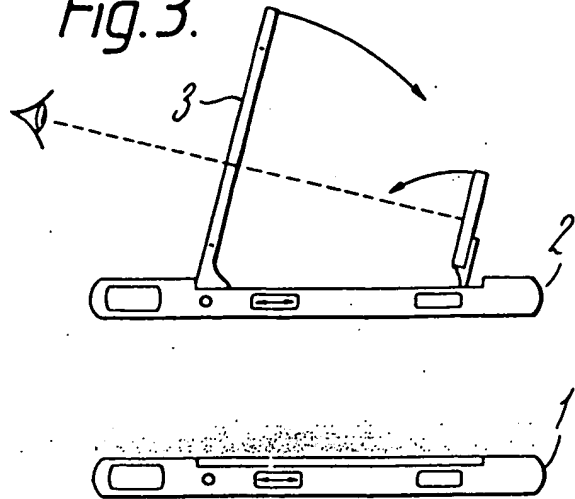
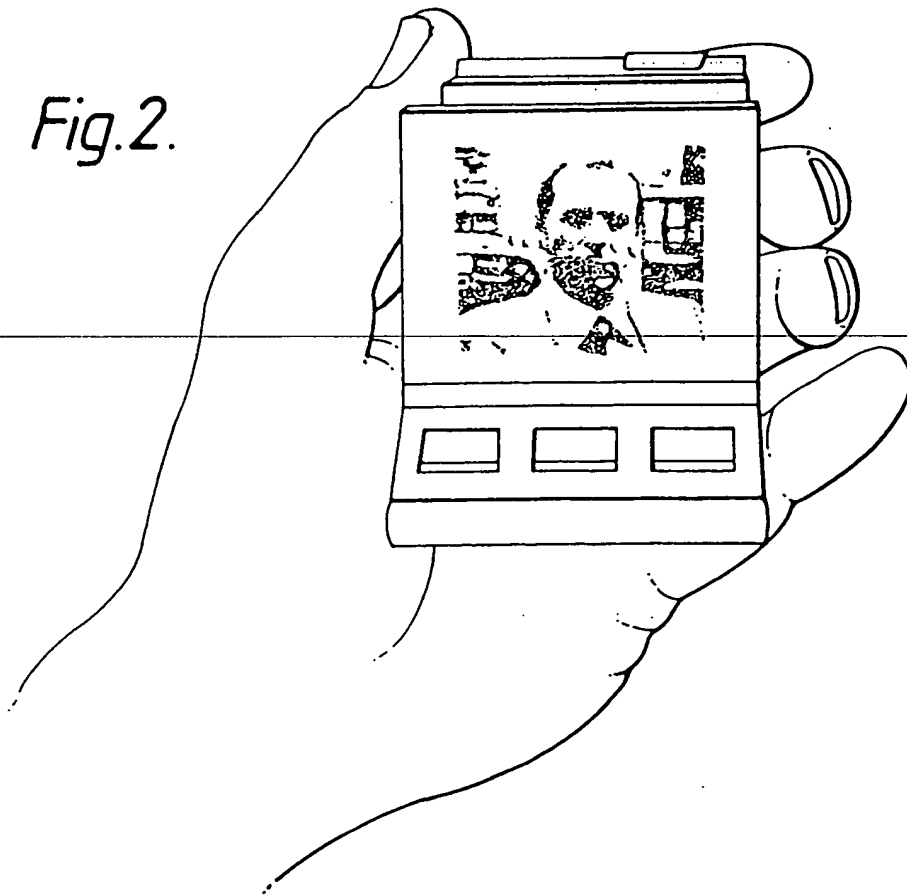The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1.

Fig.3.

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Fig.2.

Fig.4.

Fig.5.

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Fig. 6.

Fig. 7.

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Fig. 8.

Fig. 9.

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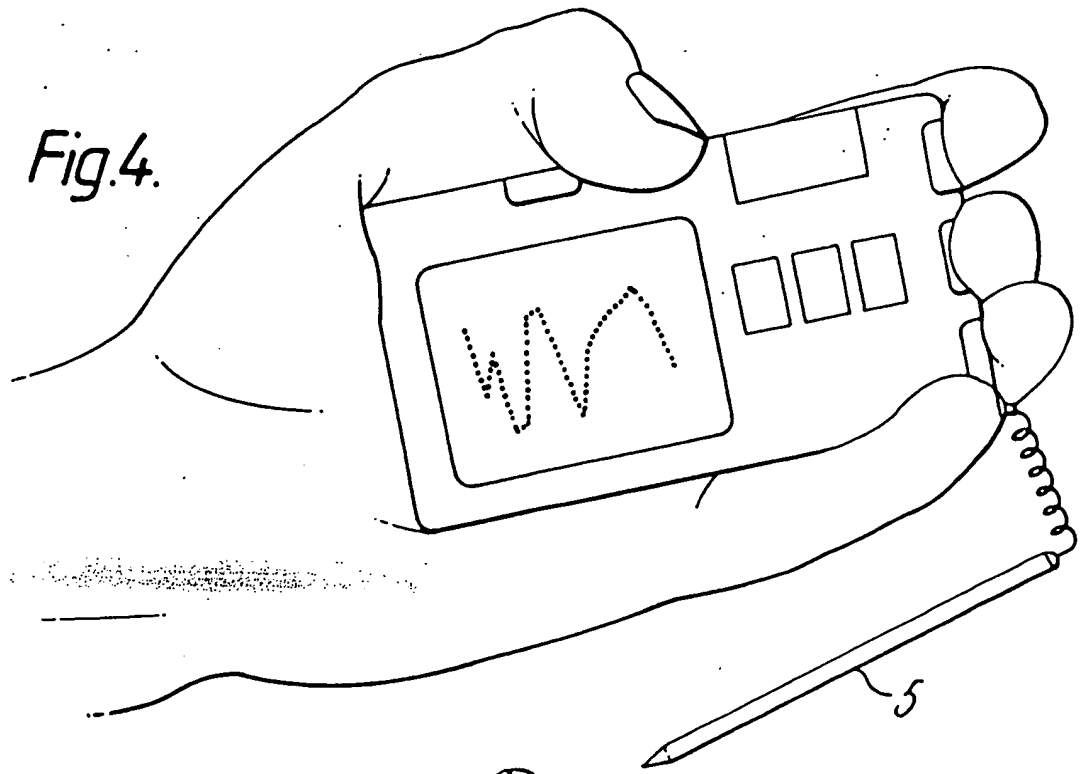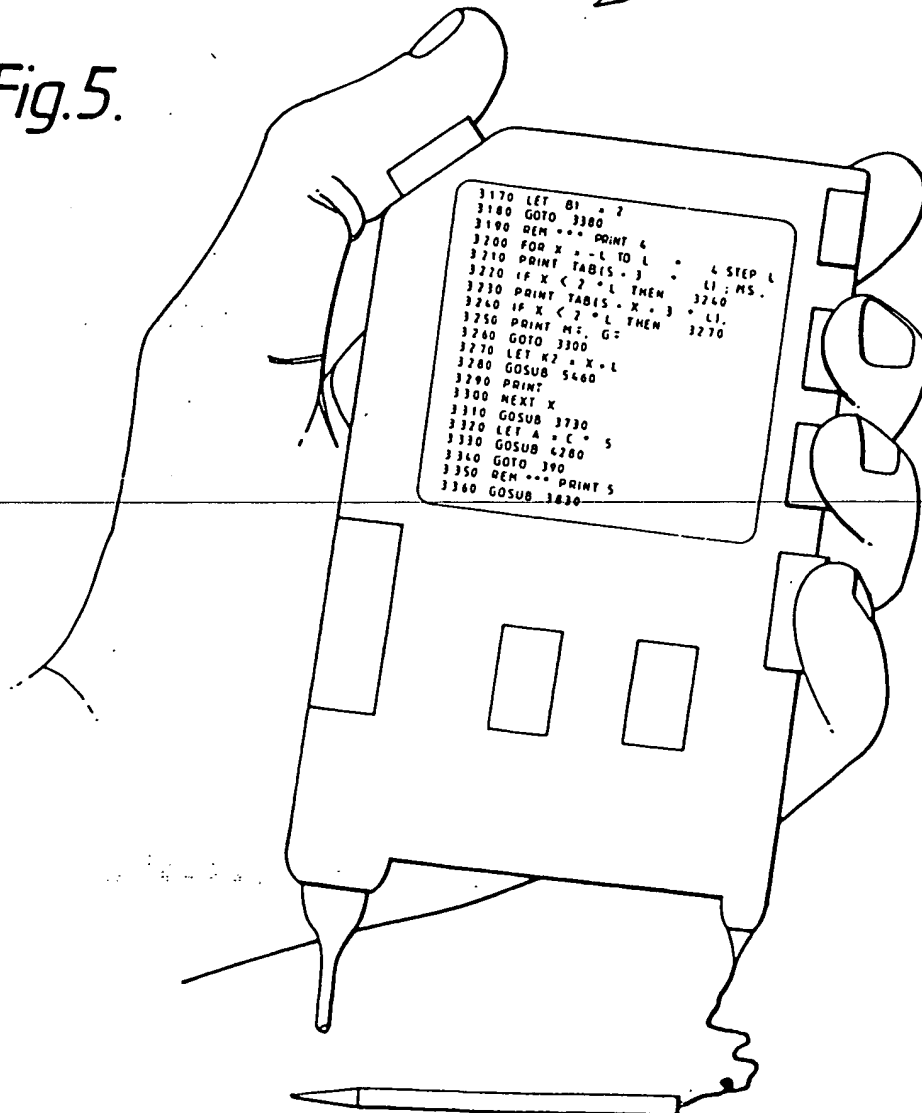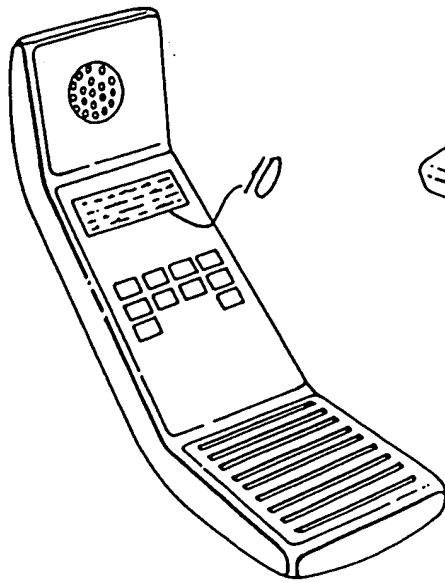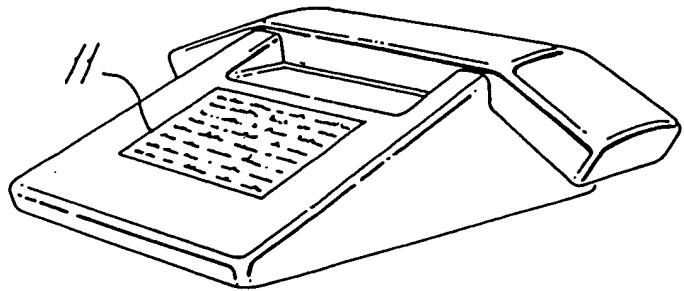
Fig.10.

Fig.11.

SPECIFICATION

Data terminals

5 This invention relates to data terminals and other devices in which visual display devices (VDUs) are used.

According to the invention, there is provided a data terminal provided with a visual display unit
10 (VDU), wherein the VDU is a liquid crystal display device formed on a silicon slice, wherein the drive circuitry for the display device and some at least of the other associated circuitry thereof are formed on the same silicon slice as is the display, wherein the
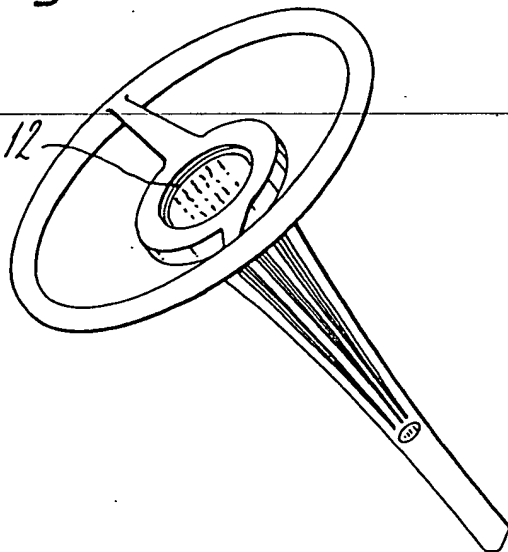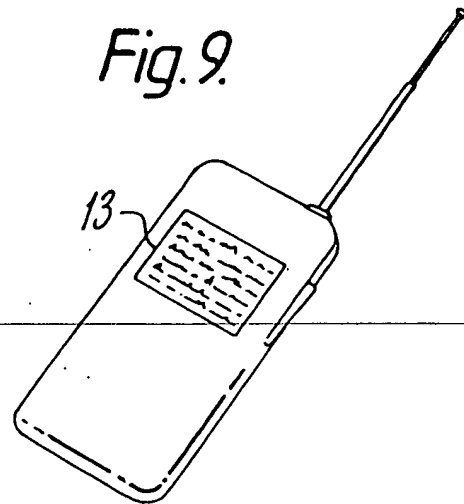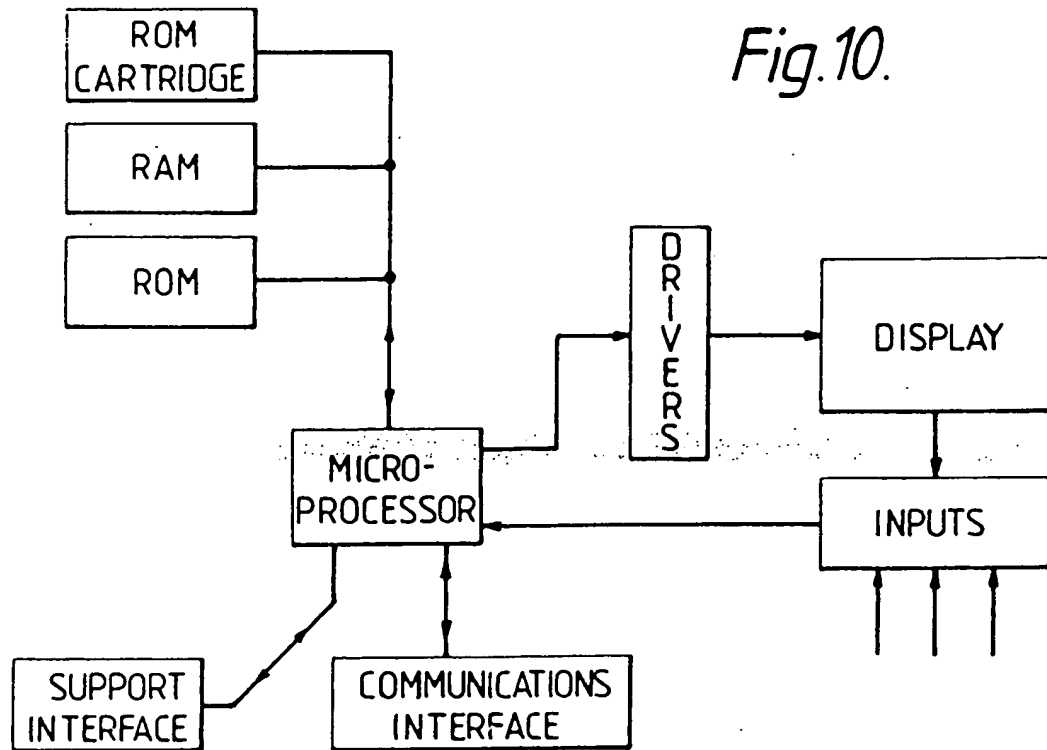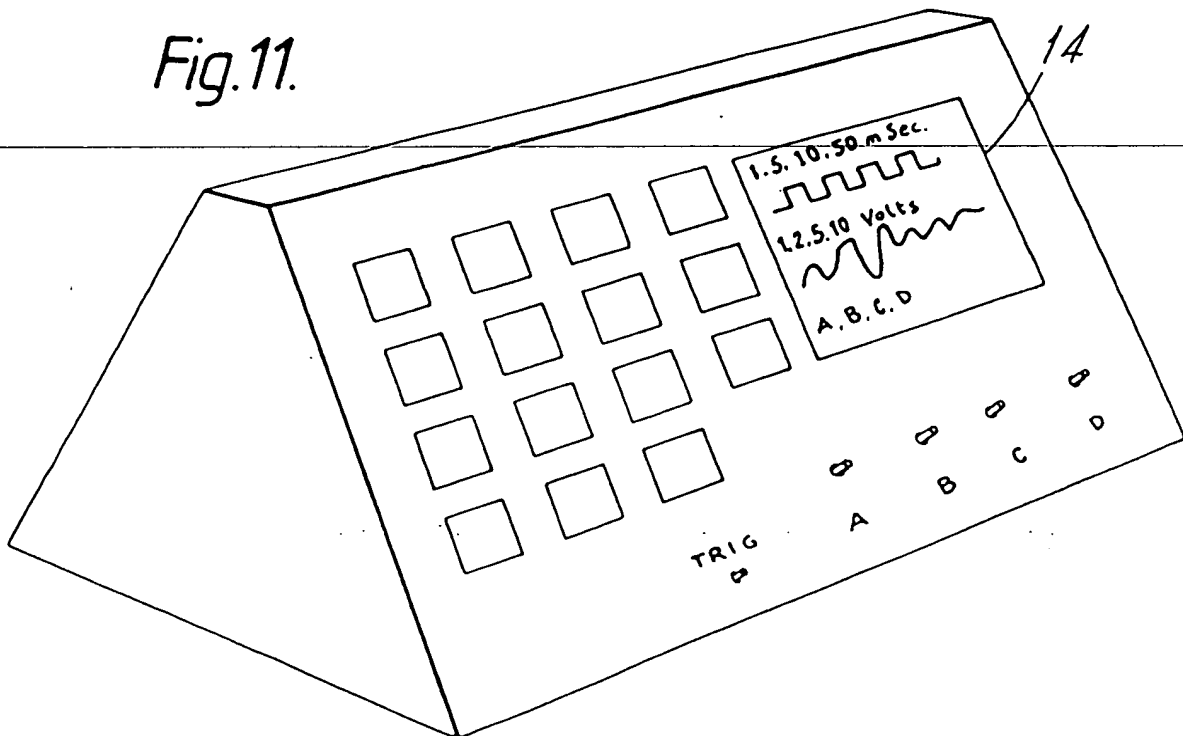15 control of the terminal is effected by a microprocessor having associated with it memory means, wherein the memory means includes read-only memory (ROM) which contains, when the terminal is in use, programmes for the microprocessor and other relatively
20 permanent data associated with the operation of the terminal, wherein the memory means also includes random access memory (RAM) which contains, when the terminal is in use, non-permanent data such as data to be displayed by the VDU, and
25 wherein the terminal also has inputs via which the data to be displayed and other non-permanent data are received.

Embodiments of the invention will now be described with reference to the accompanying draw-
30 ings, in which Figures 1 to 9 show a variety of data terminals embodying the invention, Figure 10 is a generalised circuit for the control arrangements for the device embodying the invention, and Figure 11 is a flat screen embodying the invention.

35 The terminals to be described herein use liquid crystal displays (LCD) over silicon, and such devices are described, inter alia, in our Application No. 2079022 (W.A. Crossland et al 30 etc.) and No. 2118346 (W.A. Crossland et al 34-6-4). Like all LCD
40 displays except smectic, the information on the display needs to be continually refreshed. Each picture element (pel) of the display is separately addressable through a field effect transistor fabricated on the silicon backing slice. The arrangement
45 and addressing mechanisms may follow the principles set out in our Application No. 2118347 (W.A. Crossland et al 35 etc.). The association of capacitance with the pel is advantageous as it maintains the voltage on the pel for longer than would
50 otherwise be the case, thus reducing the refresh rate compared with would otherwise be necessary. Compared with other LCD displays of the nematic or cholesteric variety, which are not on a silicon or similarly-performing backing layer, the require-
55 ments of the refreshing circuits are much less onerous and the maximum number of elements that can be addressed while not infinite is less severely limited. In this respect attention is directed to our Application No. 2113444 (P.W. Ross 5).

60 As the display is over a single slice of single crystal silicon, its size is limited to a diameter of about 4". This limits the number of characters it is practicable to display without the addition of some form of optical magnification.

65 Dyed phase change liquid crystal displays give good contrast, but the pixel states are essentially binary and grey scale is difficult to achieve directly. However, a grey scale can be effectively simulated by what is called "ordered dither", which is a
70 combination of space and time multiplexing over blocks of 4 × 4 pixels. Pixels alternate between black and white in time and space to give an average effect corresponding to grey level required.

Total VDU capability in flat panel data/text display
75 and graphics can be achieved in displays only 3-4mm thick by combining a black-to-white transition in liquid crystal using a dyed electro-optical effect with an addressing matrix fabricated by standard MOS processing in a silicon wafer. The
80 wafer becomes the back plane of the liquid crystal display cell. It carries both the MOS addressing matrix, with a transistor or transistors controlling the voltage on each picture element, and also provides all the peripheral MOS drive electronics back to
85 serial data feed, so that only 10-15 connections are required for a display with 60,000 or more picture elements. The displays show 'print on paper' contrast, and have no viewing angle limitations. The technology can produce high resolution displays
90 from 15mm^2 up to the full size of a silicon slice. In the former, resolutions greater than 10 lines/mm are possible. The cost per character is low since most of the display drive electronics is fabricated into the slice during the matrix manufacturing process. Addi-
95 tionally other electronics associated can also be fabricated and interconnected on the slice, for example RAM, transistors, diodes and resistors. Normally the display is square or rectangular whereas the slice as cut from a silicon single crystal is
100 approximately circular. The extreme edges of the wafer are not normally usable but segments remain between the display areas and the edges that are suitable for the integrated circuit realisation of these other functions.

105 Figures 1 to 9 are examples of data terminals embodying the invention.

The arrangement shown in Figure 1 has a display about the same size as many wrist-watches. Its viewing distance is 20-25cm, and it gives an image
110 on the retina which is about half the height of the image due to a standard TV set. The display has an areas of 4cm^2, with 200 lines, and has a scroll facility for text and zoom facility for a standard line video signal. The strap or bracelet includes receiver cir-
115 cuits, aerial and a battery, which may be partly integrated. Its input can be pager or TV receiver inputs, and it may have a miniature socket for an external programmer.

The device's functions include time/data, pager
120 and message store, diary programmed by an external programmer, off-air Videotext with scroll, off-air TV with zoom, and edge controls for screen manipulation (scroll and zoom).

Figure 2 is a hand-held or "vest pocket" data
125 terminal whose viewing distance is 25-35cm, giving a retinal image as for a standard TV set. It can have a simple magnifier, as seen in Figure 3, in which the device is shown folded at 1 and opened at 2. The device 3 is a Fresnel magnifier, giving in one case a
130 magnification of X2, of the image provided by the

display device 4. This has very similar characteristics as for an image size, and facilities, etc., as the device of Figure 1.

Figure 4 is another hand-held or "vest-pocket"
5 terminal whose retinal image and viewing distance are as for Figure 2. However, it has an area of 12cm², with 250 lines. It has the scroll and zoom facilities, and can accept standard line video systems. Its – inputs are a ROM cartridge for data files or dedicated
10 programmes, broadcast paper signals, videotext and TV, and an infra-red "light pen" 5 for data entry by "menu selection".

Its facilities are similar to those of Figures 1 and 2, but with the addition of business/scientific graphic
15 calculator using pre-programming by ROM cartridge, and data/command entry with light pen. It also has "palm of hand" screen manipulator controls (scroll and zoom).

Figure 5 is a pocket data terminal which is in effect
20 a somewhat enlarged version of the device of Figure 4. Its viewing distance is 35-40cm, with a retinal image as for a standard TV set. Its area is 16cm², with 250 lines, and it has scroll/zoom facilities, it accepts standard line video signals, and it has a light
25 pen data tablet. Its scanning can include 32K RAM.

Its inputs are "Prestel-type" telephone connections, infra-red light pen data tablet through the display (used for data and command entry, ROM cartridge for files or dedicated programmes, broad-
30 cast pager signals, and videotext and TV. Its facilities are in the main as for Figure 4, with the addition of a "stand-alone" microcomputer capability.

Figure 6 shows a terminal 10 used as a "message label" for a telephone, the terminal being handset-
35 mounted.

Figure 7 is another use of a terminal 11 in a telephone set, this time as a message unit/diary.

Figure 8 shows the use of a terminal 12 formed of a miniature display (1cm x 1cm) set in the end of a
40 steering column of a car. This provides a message pad for the driver.

Figure 9 is a pager with a terminal 13 so that it can receive telex messages, and has soft vertical scroll for message extensions. This can display four lines
45 of text, each with twenty or thirty characters.

Figure 10 shows the system block diagram.

Figure 11 is a flat screen oscilloscope in which the display 14 is in effect a data terminal display. This has an area of 12-16cm², with up to 250 lines. It has
50 the equivalent of four beams, with facilities for sample and hold, "menu selection" by button and screen legends, programmable, button functions, and external/internal triggering.

Another application of a data terminal embodying
55 the invention is as a helmet-mounted video instrument for a head-up display. Here we have a low bulk, 2cm x 2cm x 0.2cm, high-resolution flat panel display, projected to the wearer's (usually an aircraft pilot) natural viewing distance.
60 It will be appreciated that there are features common to all applications and other common to several. Rather than concentrating initially on specific applications therefore it is preferably to take a generic approach as far as the electronics (as
65 opposed to the mechanics) is concerned and de-

scribe the component parts that go together to make a system:

These are (with reference to Figure 10):

(a) *The display panel.* This is covered in general
70 terms above, and detail follows the principles set out in the patent applications referred to above.

(b) *Display drive electronics.* This is organised as a general purpose module on a matrix basis, and realised as an LSI or VLSI circuit forming an integral
75 part of the display silicon. Various specialised addressing schemes exist for use where there are specific constraints on the type of information to be displayed (e.g. oscilloscope waveforms).

(c) *Control Processor.* Control of the equipment
80 uses a microprocessor and its associated memory, of the read only (ROM) and random access (RAM) variety. The microprocessor is responsible for:

(i) Providing the information to drive the supply and to format it (scroll, zoom etc.).
85 (ii) Dealing with inputs from keys, touch sensitive overlay and "light pen"-activated matrices. This is by scanning and/or by interrupt.

(iii) Dealing with output to and input from the communications interface; the exact nature of the
90 interface is application dependent.

(iv) Access to plug-in ROM cartridges when relevant. This is a purely passive device within the address space of the processor.

(v) Access to external processor for load of
95 programmes and data and dump of data when relevant.

(vi) Running programmes stored in ROM and/or RAM to operate the unit.

(vii) Storing working data in RAM and in the
100 display drive circuitry in some cases.

(d) *Inputs.* Inputs, dependent on applications, uses buttons, touch sensitive overlay, light pen and aerial in any combination. These are conventional, with the possible exception of the light pen system,
105 where there are three options:

(i) An array of photo sensitive devices behind the display, the display itself being transparent at the infra-red frequencies used.

(ii) Photo sensitive devices built into the display
110 itself. These could be one per pixel or less (e.g. one per 4, 8 or 16 pixels). Less, because the resolution required of the input is per character whereas the characters have to be built up from many individual pixel elements. Such photo sensitive devices could
115 be diodes or transistors involving a minority carrier conduction process.

In cases (i) and (ii) it is necessary to ensure that the display drive circuits are not adversely affected by illumination. The drive circuits are majority carrier
120 devices (MOS) which are not as photo-sensitive as are minority carrier devices. Thicker metallisation over the drive circuit element (as opposed to the photo-sensitive element) can be used to increase the difference in sensitivity if necessary.
125 (iii) Use is made of the photo-sensitivity of the display drive elements at infra-red. Display elements exposed to light pen radiation are discharged and the display drive matrix already provided can be scanned to detect such discharged elements, iden-
130 tifying the character in question. A character thus

exposed to radiation disappears from the screen while being illuminated, giving positive feedback that the light pen (not in the visible spectrum) is working.

5 . The drive circuits interface to the central processor through hardware from whch the processor can determine the nature of the device, the type of signal and in the case of a matrix, the location.

(e) *Communications Interface.* This applies
10 where data communication takes place across a defined and possibly standard interface. The interface provides the necessary level conversions, "hand-shake protocols and buffer data as appropriate to its functions". It is scanned by or interrupts the
15 processor.

(f) *Support Interface.* This allows the terminal to be supported by an external processor (w.g. proprietary microprocessor system). The design of this interface is dependent on the interfaces that system
20 supports. RS232, IBM 2780/3780 or Ethernet are some possibilities. When the support and communication interfaces use the same protocol they may be combined as one. The implementation of the support interface is similar to that of the communica-
25 tions interface.

(g) *Power Supplies.* The majority of applications demand internal batteries which can be of the primary (throw away) or secondary (rechargeable) type. In the latter case a socket will be provided for
30 the connection of an external battery charger. For some applications, such as vehicles or telephone equipment, use can be made of an external (battery) supply.

35 CLAIMS

1. A data terminal provided with a visual display unit (VDU), wherein the VDU is a liquid crystal display device formed on a silicon slice, wherein the
40 drive circuitry for the display device and some at least of the other associated circuitry thereof are formed on the same silicon slice as is the display, wherein control of the terminal is effected by a microprocessor having associated with it memory
45 means, wherein the memory means includes read-only memory (ROM) which contains, when the terminal is in use, programmes for the microprocessor and other relatively permanent data associated with the operation of the terminal, wherein the
50 memory means also includes random access memory (RAM) which contains, when the terminal is in use, non-permanent data such as data to be displayed by the VDU, and wherein the terminal also has inputs via which the data to be displayed and other
55 non-permanent data are received.

2. A data terminal as claimed in claim 1, wherein the terminal is mounted on a strap or bracelet which fits round a user's wrist, and wherein the strap or bracelet also carries circuit elements and a battery.
60 3. A data terminal as claimed in claim 1, wherein the data terminal is a hand-held device in which the display is hingedly supported, and wherein the terminal has a Fresnel magnifier which is also hingedly supported.
65 4. A data terminal as claimed in claim 1, 2 or 3, and wherein the device has a light pen for the input of information.

5. A data terminal as claimed in claim 1, wherein the terminal is part of a flat screen oscilloscope of
70 which the liquid crystal display is the screen.

6. A data terminal, substantially as described with reference to Figure 1, Figures 2 and 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 or 11 of the accompanying drawings.